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California Power Authority

Mr. Chairman, Members of the Board

My name is Jim Salisbury. I represent Pacific Agribusiness and have been attending these meetings and following the public debate on behalf of Compact Power, a U.K. manufacturer of advanced thermal treatment equipment, and Dry Vac Environmental, a California manufacturer of drying equipment for highly aqueous wastes.

Compact Power has developed a total waste-to-energy solution for local communities using pyrolysis, gasification and high temperature oxidation. Its advantages are based on the ability to provide an economic and effective process for municipal solid waste (MSW) and a wide range of other solid and aqueous wastes, including primary sewage. The process enables recovery of up to 80% of the energy value of the waste fuel as usable heat and power. In addition to power generation, valuable by-products are recovered, principally carbon and inert residues. Operations meet the highest emission standards.

We would like to see this process included with your other identified renewable energy technologies: fuel cells, micro turbines, and solar PV modules.

We strongly support the Power Authority's "Clean Growth Plan" with its sound energy and environmental strategy. We believe that the Power Authority has a vital purpose as the agency to implement this strategy because the Power Authority controls the two requisites to success: a long-term perspective and dedicated financing.

We also support your willingness to be the champion of renewable energy and to work with other agencies. Among these other state agencies, we encourage you to work with the Integrated Waste Management Board in their efforts to convert MSW directly to energy. They are taking a strong look at MSW since, as they put it, we can't keep sticking it in holes in the ground. We believe that direct conversion to energy through Compact Power is the best solution for MSW.

We also support the Power Authority's emphasis on decentralized, homegrown sources of power. Local generation advances efficiency and air quality as well as transmission security. The modular nature of the Compact Power/Dry Vac units are capable of expanding to meet local generation and waste disposal needs.

The job creation and economic development advantages of these combined thermal conversion and drying technologies are important and two fold. First, development of this renewable energy tool will be a new California industry. DryVac is a rural California company with an existing work force and expanding international sales. Compact Power has agreed to establish a California manufacturing facility to serve the North American and Asian markets.

Secondly, the combined technologies permit the development of complementary businesses capable of utilizing the heat, power, and other by-products of the Compact Power process. For

example, Compact Power has the capacity to produce industrial quality carbon black from processed tires. Activated carbon can be derived from sewage sludge. Agricultural and other biomass wastes, some containing high concentrations of fertilizers or animal by-products, can produce other recycled components in addition to their efficient waste disposal through energy conversion. The technologies also have applications in environmental remediation, including Green Field sites and correction of environmental injustices derived from the location of aged and dirty fossil fuel plants. The Compact Power/Dry Vac technology is designed to provide some practical and economic waste-to-energy solutions for the developed world and also provide some much needed solutions for developing countries.

These technologies develop clean renewable energy. In addition, they produce their energy from waste that would otherwise generate higher economic cost and further degradation of soil, water and air resources through "disposal," trucking and other handling. As Chairman Freeman has pointed out, the externalities of clean air and a clean environmental are value-laden issues. We believe our technologies speak to these values.

We encourage the Power Authority to commit financial resources to this proven technology and help move this fledgling industry to a California-dominated world wide economic activity.

Thank you for your time.

Compact Power Puts Pyrolysis at the Heart of Sustainable Developments Optimising Value Recovery

Nic Cooper, Compact Power Limited

EXECUTIVE SUMMARY

Compact Power has developed a total waste solution for local communities using pyrolysis, gasification and high temperature oxidation. Its advantages are based on the ability to provide an economic and effective process for a wide range of wastes, to recover up to 80% of the energy value of the waste fuel as usable heat and power, and to operate to the highest environmental standards.

The process can facilitate the recovery of materials, principally carbon and inert residues, in the form of valuable by-products. As such it constitutes a form of "thermal recycling".

The technology has been developed over a period of 8 years and is now being demonstrated in a commercial plant running in Avonmouth in Bristol, UK. The operations are carried out under an Integrated Pollution Prevention and Control Authorisation from the Environment Agency and emissions are continuously monitored and reported daily in accordance with the authorisation. Results show that operations are well within permitted limits and in some respects new standards are being demonstrated.

The process holds all material for nearly 1½ hours at high temperature in a closed system during which it is first pyrolysed in the absence of oxygen to release the hydrocarbon gases and leave carbon and inert residues. The carbon is either captured for conversion into high value carbon products, or reacted with steam and air to produce hydrogen and carbon monoxide. The gases are then taken forward for combustion through high temperature oxidation at 1250° C for more than 2 seconds. Energy recovery is achieved through a steam boiler and steam turbine. Emissions meet the highest standards and dioxins are undetectable.

The ability of the plant to process multiple waste streams simultaneously gives the potential for optimizing a total waste solution for a community. The combination of the technology with DryVac sludge drying plant provides an economic solution for highly aqueous wastes and represents a technical breakthrough for wastewater treatment. An integrated closed system returns clean water to the system and valuable materials are recovered from the solid content.

Compact Power seeks to maximise the opportunities for sustainable development around its projects by collaborating with complementary activities that can use the heat and power and other by-products from the Compact Power process. It is, for example, developing the capacity to produce industrial quality carbon black from processed tyres. Similarly the Compact Power technology for production of activated carbon from sewage sludge will offer

the water industry the opportunity to recycle a high value product for its operations from its own waste stream.

In the field of conversion of biomass, including a wide range of agricultural wastes containing high concentration of fertilisers, the Compact Power technology is designed to provide some practical and economic solutions for the developed world which will also provide some much needed answers for developing countries.

KEY WORDS

pyrolysis gasification recycling energy carbon water waste

INTRODUCTION

History

The business of Compact Power was established in 1992 by Nic Cooper and Professor John Sharpe, an expert on thermal power plant. The founders identified a niche in the market for waste-to-energy plant, appropriately engineered to provide economic answers for local integrated waste management facilities with minimal environmental impact. It is based on a modular concept to give the best options for matching the variable requirements of truly sustainable solutions.

The company has developed a proprietary technology for processing a wide range of wastes based on the processes of pyrolysis, gasification and high temperature oxidation. These processes permit the highest relevant environmental standards to be achieved and offer the potential for maximising the reuse and recycling of materials. The high level of energy recovery in the form of heat and power enables the technology to support complementary processes and promote job creation at local level.

A full scale prototype plant was built in 1994 based on a single pyrolyser tube with a throughput capacity of 3,000 tonnes a year; and between 1994 and 1997 a series of trials were conducted on a variety of wastes, including dewatered sewage sludge, MSW, clinical waste, waste from vegetable oil refining, tyre crumb, and coal slurry. These tested the core thermo-chemical processes and provided data on the performance of the plant and on emissions and solid residues. The results indicated that the emissions fell within or close to all relevant standards without any air pollution control equipment and that the plant could achieve the highest environmental standards with minimum conventional flue-gas remediation.

Subsequently a commercial plant was built at Avonmouth in Bristol with double the throughput capacity, and Integrated Pollution Prevention and Control Authorisation was obtained from the Environment Agency in October 2001. Since then the plant has been taking clinical and municipal waste and demonstrating the performance of the plant in normal operating conditions.

The company is also pursuing further technology developments with the object of creating applications for the re-processing of waste materials to create useful and, in some cases high value, industrial products. Currently the particular focus is on the production of activated carbon and carbon black.

The Technology
Compact Power combines the thermo-chemical processes of pyrolysis, gasification and high temperature oxidation.

Compact Power converts up to 80% of the energy value of the waste into readily usable steam with a wide range of applications such as power generation and combined heat and power ("CHP"), including process heat for industrial purposes (such as the DryVac dewatering process), chilling and refrigeration requirements using absorption chillers, and water de-salination plant.

Solid wastes are converted into simple gases and used to generate heat and power. The plant is effectively a gas production plant integrated with a gas fired steam boiler and power plant. The plant is a closed system and the only emissions are the exhaust gases, which are well within the relevant emissions standards, and the ash which typically is high quality bottom ash which may be suitable for uses in construction.

The plant design permits accurate control and optimal conditions for each separate stage of the process. Provision can be made within the same facility for the handling and processing of a range of different wastes simultaneously within an integrated waste management strategy which optimises the recycling, reprocessing and energy recovery potential of each waste stream.

Pyrolysis
The waste is initially fed into a system of tubes in which pyrolysis takes place over a period of about 30 minutes. The material is heated in the absence of oxygen. In the temperature range 400° to 800°C the organic materials break down into "pyrogas" (low molecular weight hydrocarbon gases), leaving carbon residues and inert materials such as ash, metals and glass, all of which pass into the gasification chamber.

Gasification
This is the process by which the residual carbon is reacted with steam at high temperature to produce hydrogen and carbon monoxide which are both combustible gases, and carbon dioxide. This is the conventional "water gas" reaction and takes about 1 hour.

High temperature oxidation
The pyrogas and the water gas pass into a thermal oxidizer which is maintained at a constant temperature of 1250°C. Sufficient air is introduced for complete oxidation of all gases and the design of the chamber ensures that the gases and any small particles of solid matter that may come through in the gas stream remain at these temperatures for at least two seconds. These conditions are designed to minimise the emission of pollutants and to meet the highest environmental standards.

The exhaust gases from the thermal oxidizer provide the heat for the process, and the plant is self-sustaining even with wastes which have relatively low calorific value. However auxiliary fuel is used to ensure that the temperature conditions in the thermal oxidizer are maintained at all times and to enable the plant to maintain the required heat and power output even if the energy value of the waste is inadequate or if the processing of the waste is interrupted for any reason.

The exhaust gases then pass through a boiler where the heat is transferred to the steam and the temperature of the gases is rapidly reduced to below 250°C. The steam is then available as a convenient energy source for heat and power applications.

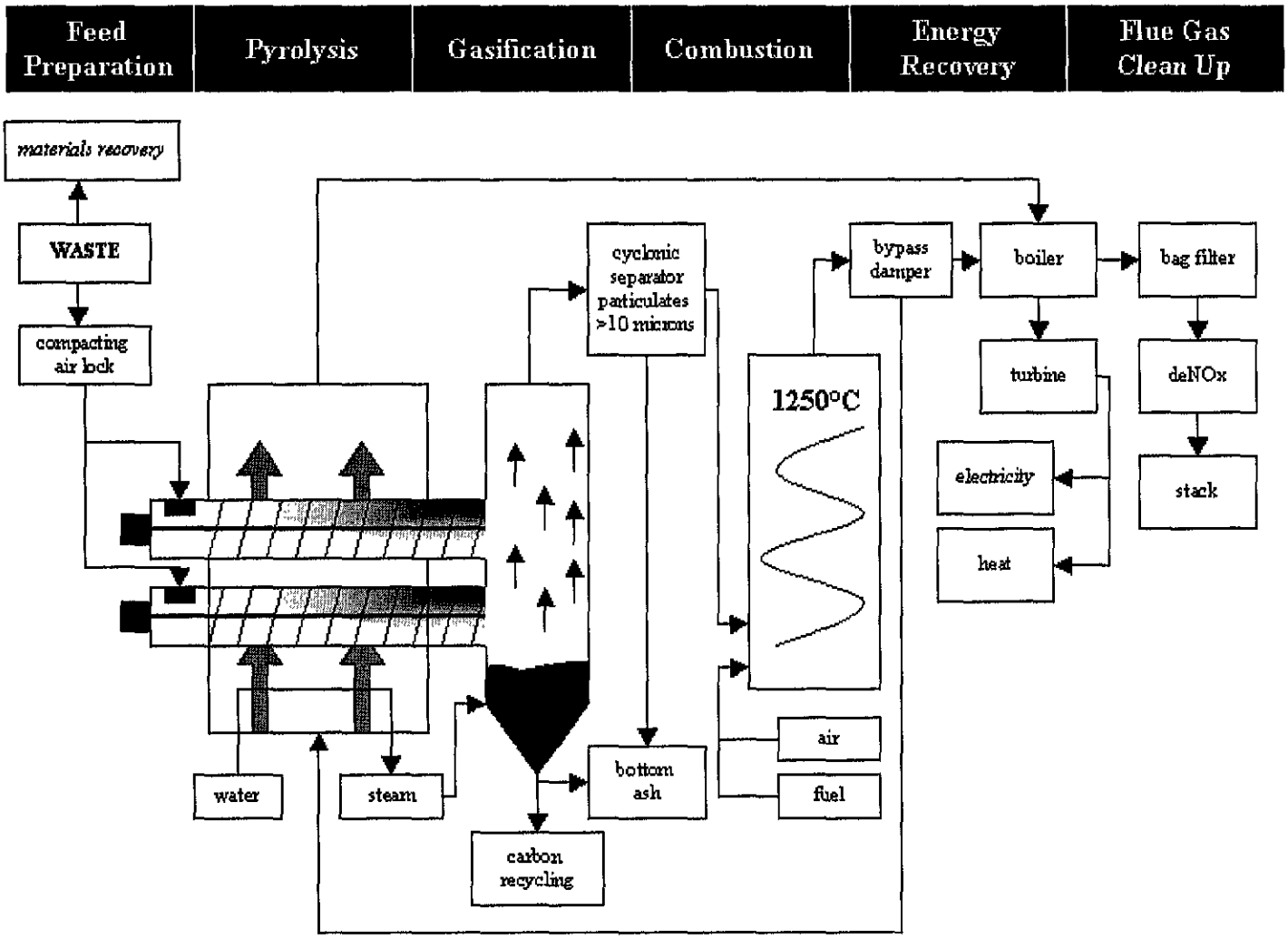

Figure 1
Process diagram of Compact Power technology

Emissions control and ash

The process is designed to minimise the risk of dioxins arising and the gas clean-up system has the capability to reduce any residual dioxins in the flue gas. Similarly such nitrogen oxides ("NO_X") as are produced are brought well within all relevant standards by the de-NO_X unit included in the flue gas clean-up system.

Any solid residues will be removed from the plant. Ash will be recycled to the extent that this is practicable or otherwise sent to landfill. The amount of ash will depend on the characteristics of the waste fuel.

Plant design

Compact Power's designs are based on the principle of compact, modular units of plant which are used to produce integrated systems for waste to energy and CHP applications. The items of plant are designed to be transportable so that they can be modified or relocated to meet changing needs and varying waste streams.

The multi-tube pyrolysis system is based on 2 tube units each with a 1 tonne per hour throughput capacity. Each 2 tube unit feeds a single gasifier. There is a standard 2 tube (MT2) system or a standard 8 tube (MT8) configuration made up of 4 x 2 tube units. The gas line / thermal oxidizer (G) is sized to serve an MT2 or an MT8. Facilities are designed around combinations of these units, so that a unit designed to process 64,000 Tpa would comprise 2 MT8 units and 2 oxidisers [2xMT8 (2G)].

Typical configurations are as follows:

The MT2 unit which can process up to 8,000 tonnes per annum and is appropriate for lower volume difficult wastes which command relatively higher gate fees such as clinical waste;
The MT8 unit which in the case of MSW has a capacity of up to 32,000 tonnes per annum and can generate up to 2MW of electricity (net of plant requirements) and 10.4MW of reusable heat.
The 2xMT8(2G) with a capacity of up to 64,000 Tpa of mixed waste and can generate up to 4.2MWe and 20.8MW of heat.
The 2XMT8(3G) with a capacity of up to 64,000 Tpa of mixed waste including highly calorific waste such as tyres and can generate up to 7MWe and 31.2 MW of heat.

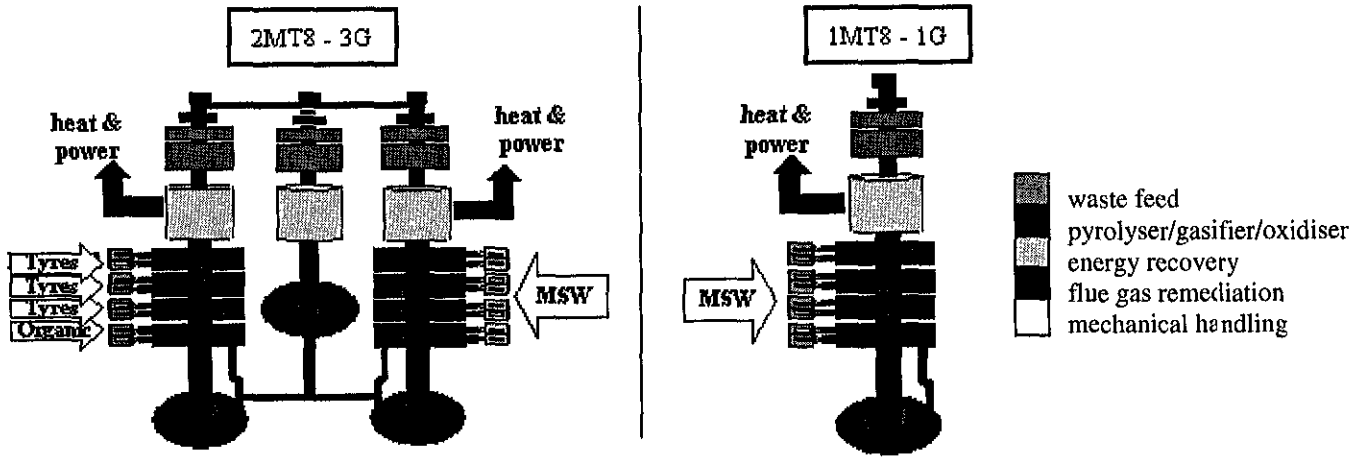

Figure 2 Modularity of Compact Power plant

The plant is designed to provide economies in operation and maintenance with features that minimise the risk of unscheduled stoppage. A principal design criterion is the achievement of the environmental objective set by the U.K. Environment Agency to use Best Available Techniques ("BAT") to avoid or minimise harmful pollutants from any process. The combined effect of pyrolysis, gasification, high temperature oxidation and advanced NO_x treatment

minimises pollution to such an extent that we believe that the process can offer the best environmental options for waste disposal.

Compared with a typical mass burn incinerator, the system has very low environmental impact in terms of air pollution and discharges of residues to land. There is no aqueous waste effluent and the plant has a low visual impact compared with a typical mass burn incinerator.

Table 1
Emissions data

Mg/Nm^3 11% O_2 @ 273K & 101.3kPa	EU Directive Limits		Compact Power
	s: spot / d: daily	½ hour	
Particulates	10 (d)	30	0.2
VOC's as carbon	10 (d)	20	trace
NO (NO + NO_2)	200 (d)	400	<37
HCl	10 (d)	60	2
HF	1 (d)	4	<0.1
SO_2	50 (d)	200	< 25
CO	50 (d)	150	trace
Cd & Tl	0.05 (s)		0.006
Mercury	0.05 (s)		0.006
Pb Cr Cu Mn Ni As Sb Co V Sn	0.5 (s)		0.006
Dioxins TEQ ng/Nm^3	0.1 (s)		<0.003
N_2O	30 (d)		trace
NH_3	10 (d)	20	< 1

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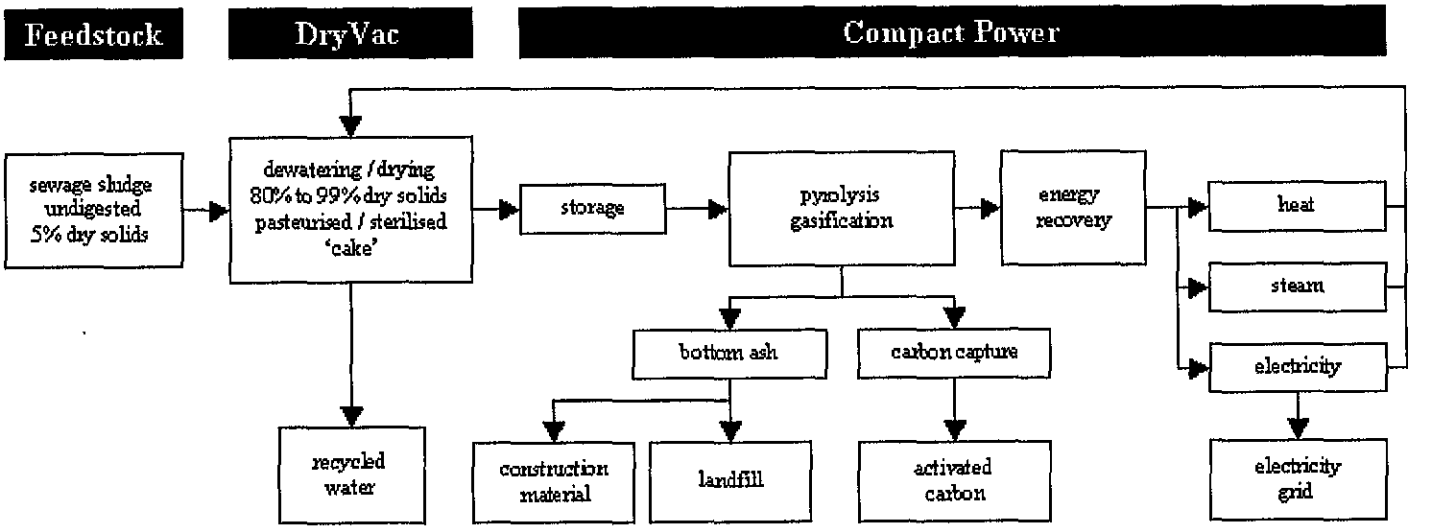

Figure 3
Process flow of combined Compact Power / DryVac application

Compact Power seeks to maximise the opportunities for sustainable development around its projects by collaborating with complementary activities that can use the heat and power and the other by-products of the Compact Power process. It is, for example, developing the capacity to produce industrial quality carbon black from processed tyres. Similarly the Compact Power technology for production of activated carbon from sewage sludge will offer the water industry the opportunity to recycle a high value product for its operations from its own waste stream.

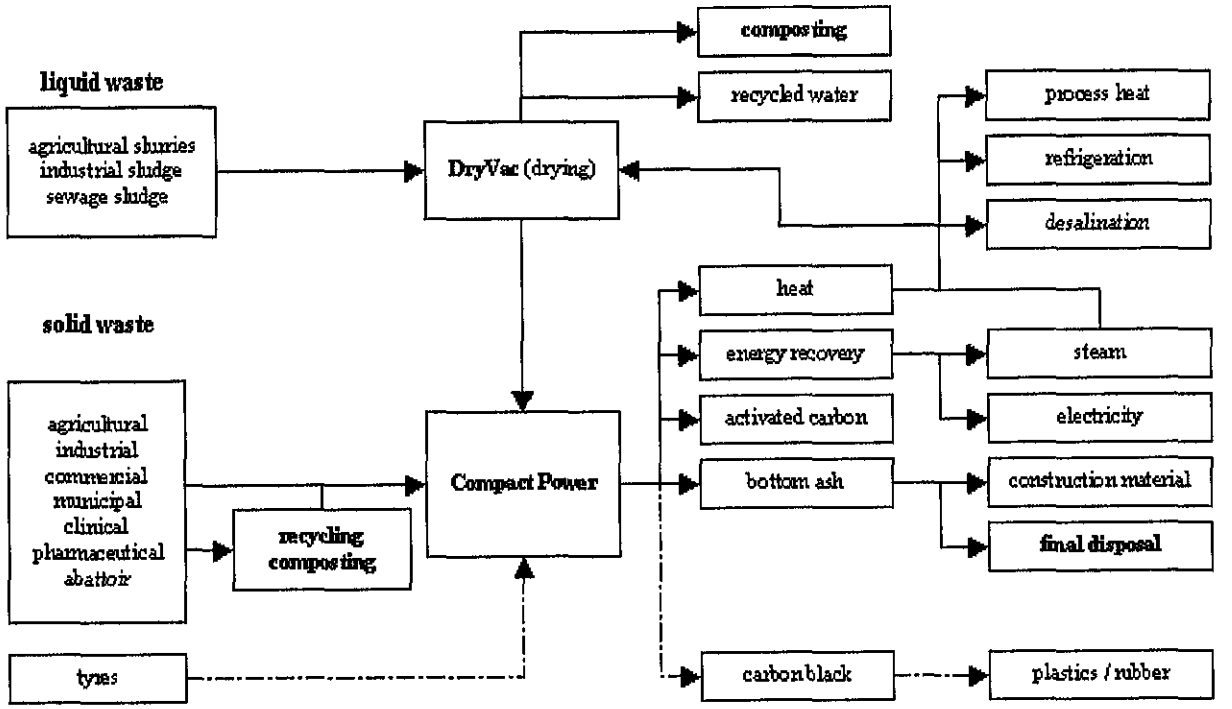

Figure 4
Process flow of typical integrated waste management facility

In the field of conversion of biomass, including a wide range of agricultural wastes, the Compact Power technology is designed to provide some practical and economic solutions for the developed world which will also provide some much needed answers for developing countries.

Case studies will be presented of different applications of the technology in project situations.

CONCLUSION

Compact Power has a "hub and spoke" approach to project development in which it can offer a total waste solution for a community at the heart of an integrated infrastructure facility. This can provide an economic process for relevant municipal, commercial and industrial wastes, recycling materials where practically and economically feasible, recycling water from aqueous wastes and contributing renewable energy to local distributed power systems. Environmental objectives of reducing carbon emissions can be met by converting carbon residues.

The Compact Power process is conceived more as a thermal re-processing of waste with optimised energy recovery than as a means of disposal and the company's business is dedicated to realizing this potential for truly sustainable solutions in partnership with industries and the communities which they serve.

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